READING ABILITY AND THE EFFECTS OF PERCEPTUAL MODE ON LEARNING AND RECALL OF PAIRED ASSOCIATES WITH ACOUSTIC OR GRAPHIC SIMILARITY

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ABSTRACT

READING ABILITY AND THE EFFECTS OF PERCEPTUAL MODE
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By

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The theory of intersensory integration has been applied to early childhood development and to reading disability in later childhood. The purpose of this study was to compare three hypotheses of perceptual integration, the first stated in terms of presentation mode only, and the second and third stated according to concepts of first-order input (the presentation mode) and second-order input (the acoustic or graphic critical features of content). One, slow readers are deficient in the ability to integrate information presented in two modes, auditory and visual. Two, reading ability depends primarily upon the ability to form the grapheme-phoneme unit, i.e., to integrate acoustic critical features of visually presented stimuli. Three, slow readers, unlike better readers, have difficulty integrating graphic critical features presented auditorially and also acoustic critical features presented visually, the mode-content combinations that represent the intersensory combinations across first- and second-order input.

A sample of average or better readers and a sample of slow readers were drawn from the male population with intelligence scores in the 90-110 range in the third- and fourth-grade classrooms of three predominantly white, middle-class schools.

The subjects learned two paired associate lists in which the

stimulus and response terms had acoustic or graphic similarity. In the intersensory condition, the stimulus term of the pair was presented visually and the response term auditorially. A second treatment group received the same lists presented in a strictly visual form. A third treatment group received the same lists presented in strictly auditory form. Visual stimuli were presented on a memory drum and auditory stimuli with a tape recorder. Half of each treatment group received the graphic list first, half the acoustic list first. Following trials to criterion, subjects were given tests for backward recall.

It was hypothesized that the learning rate of the slow readers is sensitive to effects of the order of list presentation while better readers do not show this sensitivity. It was also predicted that the slow and better readers would differ in their patterns of response to the six mode-content combinations.

Analysis of variance of the number of trials to criterion indicated that of the three contrasting theoretical positions, the hypothesis predicting a slower rate of acquisition by the slow readers in the visual-auditory condition analogous to Birch's auditory-visual integration test was not supported, nor was the hypothesis that the slow reader requires more trials than the better reader in both the visual-acoustic and auditory-graphic mode-content combinations. The hypothesis that the visual-acoustic combination corresponding to Gibson's grapheme-phoneme unit is the source of difficulty for the slow reader and not the better reader was upheld.

The order in which lists were presented appeared to affect the performance of the better readers only. Those who received the acoustic list first learned it in fewer trials than the better readers who received the graphic list first and also in fewer trials than the slow readers of both groups. Across orders, however, the patterns of response to the six mode-content combinations were similar for the two reading level groups.

An interesting finding was the interaction of mode, list and order. In the visual mode, the acoustic pairs were relatively difficult to learn, regardless of order. In the auditory mode, the difficulty of the graphic and acoustic lists appeared to depend upon the list which was learned first; when the acoustic list was learned first, both lists were learned in relatively few trials when compared to the number of trials required in the condition in which the graphic list was learned first. In the visual-auditory mode, both lists were learned with relatively little difficulty and list order had no effect.

The findings were discussed in terms of the manipulation of the child's perceptual input in reading training and remediation and also perceptual integration theory.

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CHAPTER I - THE PROBLEM

Various forms of perceptual dysfunction are among the more frequent causes given for reading retardation when children of similar past exposure to instruction and intellectual ability are compared. It is impossible to define the process of reading in the early stages without the use of perceptual terms, but the role of perceptual process and perceptual abilities in relation to reading ability is far from clear. The results of tests of auditory and visual discrimination and memory are often used by teachers to determine the type of remedial program for retarded readers.

There are several fundamental approaches to the study of perception in relation to reading ability. One approach assumes that either an imbalance exists between the auditory and visual abilities or the two perceptual functions are equally adequate or inadequate to the demands of the reading task at a given age. If perceptual imbalance (sometimes termed perceptual bias or perceptual dominance) is believed to be associated with reading retardation, then this approach attempts to identify the particular population in which the deficient process can be described. A second approach is to assume that the imbalance is specific to no group defined by socio-economic level, age, sex or other variable, and therefore must be dealt with on a completely individual basis. A third approach is to assume that if both auditory and visual processes are inadequate in the retarded reader, a general

learning deficit would be said to exist. However, this approach has not received experimental support. In fact, several studies have shown that auditory and visual abilities are independent (Butenica, 1968; Rudnick and Sterritt, 1967), and also that visual input is processed differently than auditory input (Schulz and Hopkins, 1968).

If discriminative and memory functions in both modes are believed to be adequate, reading retardation might be accounted for by a deficiency in a higher-order process. Such a process has been termed intersensory integration, in which input in two sensory channels must be consolidated as a unit in order to encode the unit for memory.

Each of these basic positions has given impetus to different hypotheses for research and the teaching of reading. The position of the present study is based on a derivation of a theory of perceptual integration. It is assumed that the perceptual deficit involved in reading retardation is not related to an imbalance in perceptual functions nor a general learning deficit, but to difficulty in the integration of second-order perceptual input in relation to the modality in which it is presented.

Elimination of the perceptual imbalance hypothesis was based on the fact that although the results of studies using standardized tests to measure the auditory and visual abilities have indicated that auditory tests are better predictors of reading achievement than visually oriented tests, experimental studies using learning tasks have not led to the conclusion that good readers are superior in or prefer auditory learning.

Some recent research has suggested that many tests used in studies of perceptual problems in reading may not be related to reading ability.

In any event, the most profitable use of experimental effort is not an attempt to show that auditory perception or visual perception is superior for a particular group, but a search for an ordering principle that will define the conditions causing auditory and visual perception to be disturbed and an attempt to show how this is related to reading retardation.

Studies of intersensory integration have been criticized for the lack of a systematic approach to the variation of stimulus dimensions (Pick, Pick, and Klein, 1967). The design of the present study included both single-sensory and inter-sensory presentations to permit examination of the counter-hypothesis of differential learning when presentation is strictly visual or auditory. It also included variation of the dimension of second-order input in the form of acoustic or graphic similarity of the stimulus material.

Integration theory. Perceptual integration in children, adults and animals is a field of investigation with a long history. Birch (1962), noting the difficulty of brain-damaged subjects in solving problems intersensorially, originated a test which required the subject to listen to a series of taps and then find the match for the tap pattern in a series of printed dots. Birch and others have used the tap-dot or auditory-visual integration (AVI) test and have found low to moderate correlations with reading achievement in grades one through six.

"The development of integrative organization between the auditory and the visual systems appears to be essential for the acquisition of reading, in which visually presented and therefore spatially distributed stimulation comes to be treated as equivalent to auditorially presented and temporally distributed stimulus patterns" (Birch and Belmont, 1965).

This statement, expressing the attributes which Birch considers to be relevant to the AVI test and early reading process, differs from Gibson's position, a theory also subsumed by the general theory of intersensory integration (Pick, Pick, and Klein, 1967). Birch's theory states that the developing nervous system progressively improves with age in the ability to achieve synthesis of input from different modalities. He has argued that perceptual discrimination precedes the level of perceptual analysis, which is followed by the stage of perceptual synthesis or integration (Birch, 1962).

From the standpoint of differentiation theory (Gibson and Gibson, 1955), the synthesis of information from different channels of input takes place from infancy and is not a separate stage of development. The difference between the infant and the older child is not the increase in the ability to synthesize perceptual input but rather the increase in the precision of the generalizations made by the child. These generalizations come about only as a result of new discriminations of complex environmental stimuli.

The complexities of the spelling-to-sound correspondences in English require the child to make many graphic and phonetic discriminations leading to generalizations about groups of letters of increasing span, the integrated units that Gibson calls grapheme-phoneme units (Gibson, 1963).

Three major points along which the two integration theories differ are the following: Birch identifies the spatial nature of visual material and the temporal nature of auditory material as the source of difficulty in the making of perceptual integrations in reading. Gibson identifies the decoding of graphic material in terms of the phonemic patterns of spoken language, a process of discovery of higher-order invariants, the spelling to sound correlations as the primary source of difficulty (Gibson, 1962).

Second, Birch holds that the degree of sensory integration possible increases with age, while Gibson maintains that it is the precision of the discriminations making up the integrated units which increase with age.

Third, matching tasks with varied modes of presentation are commonly used to investigate the Birch theory, while Gibson and others investigate the discrimination learning of the critical features in single-sensory presentation.

Birch and Gibson have discussed the role of cognitive process in relation to individual differences in reading progress. Birch found that subjects who counted or labeled the taps in the AVI test were not high scorers, but children who reported visualizing the dot pattern before seeing it performed at a higher level (Kahn and Birch, 1968).

Gibson has suggested that the child is not a passive receptor but must play an active role in the discovery of the grapheme-phoneme unit. The visual stimuli that later function as units are structured partly by feedback from response, perhaps in the form of self-stimulation such as sounding out various phonetic combinations (Gibson, Pick, Osser and Hammond, 1963).

Birch's approach assumes that when the auditory and visual sensory systems receive non-redundant information which must be integrated to

perform a task, then a difference should be found between the performance of the good and poor reader. This assumption formed the basis of the present investigation.

Gibson's position was interpreted to suggest that whenever an invariant correspondence exists between graphic and phonemic critical features and which is discoverable through self-stimulation or feedback, the child who learns to read well will be more likely to discover this correspondence than one who has not learned to read well.

The Comparability of Tasks in Different Modes. Studies of discrimination processes in reading typically vary stimulus content along the dimensions of graphic or acoustic features. No known study has employed material with both attributes studied independently and reciprocally. Past studies which compared the results of two sensory modes of presentation have employed stimuli which would adapt to both auditory and visual presentations, and the assumption, usually unstated, has been that the material presented in both modes and also intersensorially yields comparable data. For example, the stimulus content in one study was dot-and-dash patterns, printed or sounded by an electric key. The visual form of the stimulus patterns produced very few errors, while the auditory form was much more difficult. The two intersensory conditions, in which the printed or the sounded stimulus pattern was the standard to be matched with a pattern presented in the opposing mode, were of intermediate difficulty. Had the visual and auditory presentations been of equal difficulty, the relative difficulty of the intersensory condition could have been assessed (Muehl and Kremenak, 1966). In other intersensory studies, geometric forms have been presented auditorially by means of their verbal labels, visually, or kinesthetically by means of three dimensional constructions (Otto, 1961; Rudel and Tueber, 1964; Van Mondfrans and Travers, 1965). Words, printed and spoken, have been used as stimuli in an intersensory study by Budoff and Quinlan (1964).

For the present study, a type of stimulus material was sought that would be adaptable to auditory, visual and visual-auditory presentations and generalizable to the process of reading. A problem arises in that tasks in different modes are never identical, and when the two single-sensory tasks are of unequal difficulty, it is impossible to generalize to different tasks presented in the same modes. It is also impossible to make conclusions about the differences of single-sensory and inter-sensory tasks.

The solution was the construction of two paired associate lists, one with acoustic correspondence between each pair, the other with graphic correspondence between each pair. The correspondences constituted distinctive features that were analogous to the grapheme-phoneme units of Gibson's approach. It was therefore possible to examine the effects of two compatible mode-content conditions (visual-graphic and auditory-acoustic) and two conflicting mode-content conditions (visual-acoustic and auditory-graphic). By crossing modes with content types, the resultant patterns of the dependent variables can be compared even if the difficulty of one mode or one list is not equal to that of the other.

The Choice of Task. The paired associate task was chosen for the present study because it is highly adaptable to variation of both mode and content. Both members of the pair, the stimulus term and the response term, can be presented in the same mode or each can be presented in a different mode. The dimensions along which the pairs themselves can be varied are almost unlimited, and elements of correspondence along a particular dimension can be introduced either between stimulus and response terms or between pairs.

Complicating the analysis of results of paired associate studies, however, is the attribute of meaningfulness of the stimuli. Single letters, used as stimulus terms in the present study, do not have tabled ratings of meaningfulness. The meaningfulness of numbers, used as the response terms in the present study, have been tabled by Battig and Spera (1962) using adults to make the associations to the single digits. The numbers from 0 to 9 rank in the upper 25% of the tabled association values of the numbers from 0 to 100. If meaningfulness were to intervene in the sensitivity of an S to the perceptually-cued correspondence between stimulus and response terms, perceptual and transfer effects could be masked.

An additional complication is the fact that a number of studies have shown that a unique relationship can exist between pair terms that is called associability, defined operationally as a value corresponding to the number of natural-language mediators aroused by the pair (Montague and Kiess, 1968).

Furthermore, Schulz and Hopkins (1968) have concluded from a number of studies with adults as Ss that mode (auditory or visual) fails to affect performance in paired associate tasks in which the pairs have high meaningfulness. Mode does have an effect when durations of aural and visual stimuli are equated and when low m material is compared in visual and auditory presentations.

These pitfalls in the use of the paired associate task were risked in the belief that the letter-number pairs used in the present study had low meaningfulness in terms of the associability concept for the child subjects.

Choice of Presentation Mode. The kinesthetic or tactual mode is often used in studies of intersensory learning. It is also used in studies where several types of confirmation or feedback conditions are compared. In the present study, the objectives were to compare the single-sensory conditions with the intersensory visual-auditory condition and to simulate, to the extent possible, the perceptual components of the reading process that are assumed to contribute to reading retardation. These objectives determined the choice of the visual (VV), auditory (AA), and visual-auditory (VA) modality presentations.

First- and Second-Order Perceptual Input. The perceptual content of the learning material must in some way correspond to the graphic and phonetic elements found in printed words. The critical features of content are termed second-order input, while the mode of presentation is termed first-order input.

The distinction is made to emphasize certain properties of second-order input. The probability that a subject will respond to second-order input is assumed to be lower than for first-order input. In time, second-order input becomes inseparable for the observer from first-order input as the subject's responses match the correct response consistently. Second-order phonetic or graphic content would be expected to be more salient for the learner who actively explores the stimuli visually or auditorially. For example, the phoneme of the grapheme-phoneme unit when the subject is reading from the printed page is initially second-order input. The printed word is the first-order input and is responded to when the subject is given directions to trace, to name the letters, to copy, etc.

The problem for the present study was to show that the subject with a low level of reading achievement is less sensitive to second-order perceptual stimuli. The perceptual correspondences were expected to make the associations easier to recall and were expected to be discovered at a slower rate by the retarded reader.

The distinction between first- and second-order input would be academic were it not for the fact that in most studies of perceptual differences of good and poor readers, the discriminable components of the stimuli are ordinarily obviously very different. Secondly, although the ability to use mediation to form associations has been the subject of many studies, the ability to use perceptual mediators--similarities in sound or appearance of stimulus and response terms--has not been investigated in relation to presentation mode. Third, the distinction is related to differentiation theory which assumes that perceptual learning represents an increase in sensitivity to existing but initially undetected or poorly detected features of stimuli.

Change in Relevant Critical Features: Order as an Independent Variable. In the early stages of reading, before whole words are recognized as unique, beginning readers tend to rely on one or two letters of the word as graphic cues to prompt recall of the word from their reading vocabulary. The response is made to recognizable graphic features. The successful reader does not rely on this method but also responds from his knowledge of the language and the phonetic elements of the letters and letter combinations he has learned.

The retarded reader may have difficulty in alternating from the search for graphic cues to the search for phonetic cues and vice versa. Habit strength may build up differently for a particular cue. For example, if the recognition of first and last letters occasionally prompts the correct response, a set to attend to graphic cues may occur, blocking the processing of phonetic cues.

In a pilot study using auditory presentation procedures, the importance of examining the effects of a reversal of the features that are critical to a correspondence of paired associates was noted. The order of list presentation was included as a third dependent variable in the present study in order to test the hypothesis that poor readers would show the detrimental effect on learning due to the change from the acoustic list to the graphic list and vice versa. In recall of the association, the order variable also permitted the investigation of the presence of selective perception in the high and low reading level (RL) groups.

Relevance of the Problem to Reading Instruction. Basic research into the learning process when perceptual input is varied should result in findings that are directly pertinent to the teaching of reading. Methods presently in use have not been based on experimental research in intersensory learning and integration. Past studies have confounded important effects or have failed to vary stimuli systematically (Pick, Pick and Klein, 1967).

Some researchers in the field of intersensory learning have made several suggestions regarding remediation. In a comparison of auditory, visual, and auditory-visual modes, Muehl and Kremenak (1966) concluded that auditory-visual integration may be a maturational perceptual process and suggested that evidence of delayed maturation could be remedied with a continued readiness program.

Gibson, Osser, and Pick (1963) have advocated the use of materials in which the reading matter is tailored to maximize the probability that the child will discover regularities of spelling-to-sound correspondence.

Wepman (1964) and others who have taken the approach of perceptual dominance or imbalance have advocated the teaching of reading-related tasks in the dominant mode with additional training in the weak mode. It is a question whether to orient remedial assistance toward the strength or the weakness (Bateman, 1966).

The direct implications of the findings from studies by Birch and others has been that a combination of modes is more difficult. Thus, the teaching of discriminations in single-sensory presentations should be substituted. Children "who are unable to learn the names of the letters probably will not be able to learn the more complex visual-auditory associations involving whole words. Thus a continuing readiness program should be provided these children until they indicate sufficient maturity to master the letter-naming task" (Muehl and Kremenak, 1966).

The emphasis placed on the developmental aspect of the ability to integrate visual-auditory material may serve to mask the real causes of the failure to master visual-auditory material. This is especially likely to be true at the age level of the subjects of the present study who were from the third and fourth grade. Much study is needed, particularly that which defines the critical discriminable features of the second-order perceptual stimuli which are relevant to the encoding of words and parts of words, as well as the variation of first-order input.

The Correlates of Reading Achievement: Sex and Intelligence. Because reading test scores consistently correlate with intelligence in heterogeneous groups, it is common practice in studies in which other variables related to reading ability are examined to control for the variable of intelligence by restricting the selection of subjects to those who scored between 90 and 110 on a standardized test of intelligence. This was the method used in the present study. The use of covariance technique was planned if the relationship of the dependent variable to the intelligence measure used was appreciable.

Although many investigations of the reading process in children of both sexes have not included a factor for sex in their analyses, frequently only boys are used as experimental subjects. Since reading retardation is more common among boys, it was decided to limit the selection of subjects to boys for this study.

CHAPTER II - RELATED RESEARCH

There are a great number of studies investigating the effects of auditory and visual presentation of materials. However, only those studies investigating some aspect of reading ability were reviewed in connection with the present investigation. Other areas of research related to the topic of this study are: selected studies of paired associate learning, the concept of distinctive features, intersensory learning, intersensory transfer, perceptual shifting, and visual and acoustic similarity in relation to short term memory. Whenever possible, these topics will be reviewed in relation to children's learning as opposed to adult learning.

Reading Achievement and Perceptual Abilities. Several recent correlational studies have contributed to the understanding of the value of tests of perceptual abilities that are considered to be relevant to the reading process. Uhl and Nurss (1970) administered 53 tests of perceptual, linguistic, cognitive and achievement measures, including a wide range of the frequently used tests of visual and auditory discrimination and memory, retention of meaningful sequences presented visually and auditorially, concept knowledge, speed and accuracy of perception, spelling, reading achievement, motor skills, intelligence, and ability to follow directions. The 211 second-grade children tested were from families of the upper-middle or lower socio-economic level (SEL). Separate factor analyses produced several similar factors that were common to both the upper-middle SEL group and the low SEL group. The significant loadings for the upper-middle SEL group on the factor called Academic Achievement were tests of spelling, reading isolated words, and reading paragraph meaning, while the lower SEL group loadings on the Academic Achievement factor for that group were the same three tests plus oral word completion, listening comprehension, rhyming, and visual paired associates. The upper-middle SEL group produced a unique factor called Verbal Mediation, while the lower SEL group produced a unique factor called Auditory Processing. The authors concluded that the children in the two groups appeared to use different skills in two reading measures loading on Academic Achievement. The importance of auditory processing may have been due to the fact that the majority of the low SEL group spoke nonstandard American English. The fact that for the upper-middle SEL group the auditory and visual measures were not related to reading achievement is of interest to the present investigation, which has as an objective the comparison of single-sensory presentations and an intersensory presentation of paired associates.

The second study to use correlational analysis is that of Dykstra (1966). After testing 632 first-grade children with seven auditory discrimination subtests of standardized achievement batteries, he found that the knowledge of letter names, intelligence, and auditory discrimination of like and unlike beginning and ending consonants were the best predictors of reading, spelling and language skills assessed at the end of the second grade.

Second-grade good and poor readers were tested with subtests of the Illinois Test of Psycholinguistic Abilities and the Monroe Visualization Test by Golden and Steiner (1969). They concluded that poor readers were lacking primarily in auditory rather than visual functions.

Jensen has pointed out that even if perceptual factors were of themselves no longer an important source of individual differences beyond the age of seven or eight, early perceptual difficulties could have long-term effects resulting in low reading achievement. He has suggested that differences in auditory perception might persist at later ages than differences in visual perception (Jensen, 1966).

Many other studies comparing the results of the use of standardized tests have been made. Probably the results depend to some degree upon the tests themselves rather than a general "auditory skill" or a general "visual skill." One review of research in the field of auditory perception has pointed out that there is no generally accepted model of auditory perception in terms of temporality, selectivity, discrimination, etc. (Witkin, 1969).

Denison (1969), in a comprehensive review, has discussed studies of visual perception, auditory perception, studies comparing visual versus auditory presentation in both learning and diagnostic testing, studies of intersensory integration, and finally, theory and research concerning the concept of modality preference. He concludes that an understanding of perceptual abilities is vital to the learning of reading and related skills. He stressed the importance of the notion of differential perceptual strengths, suggesting that several unsuccessful attempts to show that children, when categorized according to a preferred perceptual mode, would respond to training in that mode, may have failed due to weaknesses in the training procedures as well as in the method of identification of the modality of preference. His point of view is that each child has a unique pattern of learning abilities which must be assessed with non-verbal diagnostic tests in order to identify perceptual style in the pre-school child.

In a general discussion of auditory abilities, Evans (1969) concludes that auditory acuity is probably not a factor in most reading disability cases. However, difficulties in auditory discrimination have been shown to be at least slightly associated with reading disability. He calls auditory-visual integration the third auditory skill, as indicated by the moderate correlations found between AVI performance and reading achievement by several researchers (Birch and Belmont, 1965; Kahn, 1965; Muehl and Kremenak, 1966; Sterritt and Rudnick, 1966; Rudnick and Sterritt, 1967; Beery, 1967). Pointing out the need for experimental rather than correlational research studies, Evans suggests that training in auditory discrimination or auditory-visual integration might demonstrate a causal relationship between these skills and reading achievement.

Studies of Intersensory Discrimination and Transfer. The low to moderate correlation of auditory tests to reading achievement parallels the results of correlational studies of intersensory functioning. Kahn and Birch (1968) tested 350 second- through sixth-grade boys. Using the AVI task originated by Birch in which the subject identifies visual dot patterns which correspond to patterns of taps made by the experimenter, they found correlations of .37 to .55 with the word knowledge and reading comprehension subtests of the Metropolitan Reading Achievement Battery. However, when intelligence was held constant, the correlation between the auditory-visual integration test and reading comprehension scores fell from the moderate (.50) range to the low (.20) range.

Good and poor readers matched on IQ, age and sex and from 8:9 to 13:3 years of age were compared on the AVI test by Beery (1967). Each subject received an AV form and a VA form. Both groups made more errors on the AV form, and both forms discriminated between the good and poor readers.

In an attempt to discover the dimensions relevant to the correlation of the AVI test and reading retardation, Blank and Bridger (1966) used lights as temporally distributed visual stimuli instead of taps. The results yielded a significant difference between the 13 normal and the 13 retarded readers, whose ages ranged from 9:4 to 9:11 years. When a paper dot standard was matched by the same subjects to one of three test dot patterns, no difference between the two groups was found. The investigators concluded that retarded readers are inefficient in both intermodal and intramodal perception of stimulus equivalencies, although only intramodal conditions were included in this particular study. They also concluded that retarded readers have difficulty with temporally distributed stimuli.

In a later study, Blank, Weidman and Bridger (1969) studied 24 first-grade good and poor readers matched on IQ. Again using the light flashes instead of taps, the flashes were presented both sequentially and simultaneously in a pattern. Subjects were required to identify the correct printed dot pattern from a series of three as before. The temporal presentations resulted in inferior performance by the retarded readers, although they did as well as the able readers in the simultaneous condition. This result supported the findings of the previous study.

In a third study, Blank and Klig (1970) found that four-year-old children were able to learn a crossmodal dimensional shift as readily as an intramodal shift. They concluded that because no verbal mediation could have taken place, given the task conditions, imagery or some higher-order analysis of the complex sensory input must have been used to bring about transfer. They used stimuli for which the subjects had no verbal labels. The dimensions of sensory input were tactual and visual.

The three studies by Blank et al. have shown that certain dimensions of the Birch AVI task applied to similar tasks differentiate good and poor readers, although the crossmodal condition has been eliminated.

Other researchers have continued to demonstrate a relationship between reading ability and the AVI task. Sterritt and Rudnick (1966) used a multiple regression technique with correlations of scores of 36 fourth-grade boys on each of three different tasks and reading achievement scores. The first task was administered in the manner of Birch. The experimenter tapped out the sound stimuli while the subject observed and then identified the printed dot pattern. In another task, the subject heard via headphones the patterns in tones before identifying the dot pattern. Subjects also saw light flashes in the AVI patterns before matching to dot patterns. Neither the scores from experimenter-produced taps nor light flash patterns made significant contribution to reading score variance independently of MA. Scores from the tape-recorded tone presentation of the AVI stimuli accounted for 23% of the reading score variance in addition to 46% accounted for by MA.

These investigators did a follow-up study with third-grade boys using the same procedures (Rudnick and Sterritt, 1967). Again, scores from experimenter-produced taps did not predict reading score variance independently of MA. The tape-recorded tones and the light flashes produced scores which predicted 11% and 14% of reading score variance, indicating that the intramodal as well as the crossmodal conditions may share a common factor in the prediction of reading achievement.

The presentation of the AVI test was altered in another way by Ford (1967). The experimenter produced the tap pattern by striking a metal plate under a table, hiding arm and hand movements. The correlations of the dependent variable and reading scores were lower than those obtained by Sterritt and Rudnick. The Ford sample was three times as large as the Sterritt and Rudnick sample and consisted of 121 fourth-grade boys from middle-class schools. When IQ was held constant, the correlations with scores from subtests of the Gates-McKillop and the Iowa Tests of Basic Skills dropped to the point of nonsignificance at the .05 level.

Another study designed to determine the relationship of reading ability to AVI performance was that of Muehl and Kremenak (1966). They administered a matching task to 108 first-grade children at the beginning of the school year. The VV condition required subjects to say if a printed dot-and-dash pattern was the same or different from a similar pattern. The AA condition required subjects to listen to an electrically sounded dot-and-dash pattern and then say if a similar signal pattern was the same or different. The crossmodal tasks used the same stimuli. The VV task produced the fewest errors, the AA the most, and the VA and AV tasks were of intermediate difficulty. The correlations of the two crossmodal tasks and reading scores were moderate and significant, while the two intramodal tasks produced low or insignificant correlations with reading ability. When the matching tasks were included in a discriminant function analysis with reading readiness tests, the letter-naming subtest of the Harrison-Stroud test made a large contribution to the prediction of reading performance, but none of the matching tasks, crossmodal or intramodal, made a significant contribution.

The study by Rudel and Tueber (1964) comparing crossmodal and intramodal transfer of shape discrimination by children from three to six years also found that the VV task was the easiest, the strictly tactual task the most difficult, and the crossmodal visual-tactual task of intermediate difficulty. Their conclusion can be applied to many of the studies in crossmodal and intramodal matching in which a comparison is made between the two. "The problem of perceptual equivalence across modalities does not seem to be too different from the problem of equivalence within a particular modality. The subject will utilize information from within a channel or from several channels in such a way that invariant properties are extracted." They suggest that a task comparing textures rather than shapes both visually and tactually might have resulted in the opposite order of difficulty, but "the fact remains that the crossmodal tasks were not more difficult than the intramodal task."

The studies reviewed above lead to the conclusion that crossmodal tasks such as the AVI test appear to contribute little when other tests of ability are used in the prediction of reading achievement. The moderate to low correlations with reading achievement scores were in some cases in the same range as those for intramodal tasks and reading scores. The dependence of reading ability on intersensory integration as defined by Birch is in turn dependent upon many other factors. Because subjects must compare a temporal pattern of consecutive signals, one of these factors is temporality, but the relative importance of this factor to reading ability is unknown.

<u>Paired Associate Studies in Which Mode Is a Variable</u>. Otto (1961) noted that several researchers had found that paired associate learning was directly related to reading ability. He used the anticipation method to compare the effects of three conditions of presentation of the response term: auditory, auditory plus visual, and auditory plus visual plus tactual.

In all conditions, the stimulus figure (a common geometric form) was presented and the subject responded with its verbal equivalent. Then the stimulus figure was shown again visually and the response term, a trigram, was pronounced by the experimenter, constituting the auditory condition. In the auditory-visual condition, the procedure was identical plus the presentation of a printed form of the trigram. In the auditory-visual-tactual condition, auditory and visual forms of the trigram plus a form to be traced by the subject were presented.

When the second-, fourth-, and sixth-grade subjects were compared, it was found that there was a negative relationship between grade level and number of trials, but the interaction of mode and reading level was not significant. Across groups, the auditory confirmation condition required the greatest number of trials to criterion and the auditory-visual-tactual condition required the least number of trials. Good, average and poor readers, in that order, required increasingly more trials to master the list of paired associates. Of interest to the present study was the finding that the number of re-learning trials required by good, average and poor readers was not significantly different, leading to the conclusion that once they have mastered a list of paired associates, poor readers will retain them as well as good readers.

Van Mondfrans and Travers (1965) compared nine combinations of visual or auditory stimulus and response terms in a paired associate design with adult subjects. The stimuli were familiar geometric forms or, in the auditory presentation, the names of the forms. The response terms were three-letter verbs. The design included two simultaneous presentation conditions differing only in length of exposure of the visual stimuli, and one sequential presentation condition. In the AV-AV simultaneous presentation, for instance, the subject at the same moment heard a man's voice say "square," a woman's voice say "was," saw a square figure, and saw the word "was." In the AV-AV sequential condition, the stimulus word "square" was heard, the square form was seen, followed by the sound and sight of the word "was." The investigators found that there were no differences between single-channel presentation and multiple-channel presentation. They also found that the simultaneous conditions produced more correct responses than the sequential condition. In an effort to account for this effect, they noted that in the sequential condition, each response item except the last was contiguous to both its stimulus term and to the succeeding stimulus term of the next pair.

The study by Budoff and Quinlan (1964) is relevant for its use of the paired associate technique in aural and visual formats and its comparison of average and poor readers at the second-grade level. Aural learning of the word pairs was more rapid than visual learning for both groups, an effect attributed to the use of meaningful words as stimuli. The Reading Level X Mode interaction in this study was also not significant, although it tended toward significance at the .05 level.

In a paired associate study with subjects from grades one to three, Giebink and Goodsell (1968) found that good readers required fewer trials than poor readers to learn an association between a visually presented form or figure and an orally presented four-letter verb. Presentation was sequential and mode was not included as a variable. The investigators suggested that paired associate tasks *per se* might be predictors of reading readiness, although this conclusion may not have been justified since type of task was not a variable.

Discrimination Learning and Critical Features. In the work of Gibson and her associates, discrimination tasks have been typically presented in the visual mode. In one study, trigrams were exposed tachistoscopically, and the first- and third-grade subjects reported the letters seen. The pronounceable trigrams were read more accurately than the unpronounceable trigrams. Gibson concluded that children in the early stages of reading have already generalized certain consistent predictions of grapheme-phoneme correspondence (Gibson, Osser and Pick, 1963).

In a second study, pronounciability and meaningfulness were compared since both variables could have contributed to the results of the first study. The adult subjects were shown trigrams that were rated low on pronounciability and meaning, pronounceable trigrams, or meaningful trigrams of low pronounciability. Both variables were found to facilitate reading and recall. Pronounciability was more effective for structuring units in tachistoscopic recognition, and meaningfulness was better for retention. (Gibson, Schiff, Bishop and Smith, 1964).

The distinctive features of letters were studied by Gibson, Gibson, Pick and Osser (1962). Novel letter-like forms were generated from rules which describe the graphic construction of capital letters, and 12 of these forms were chosen to be standards. Subjects of four through eight years of age matched a standard form to a form in a list containing the standard plus transformations of it which had been generated according to rules of line-to-curve, orientation, perspective, and topology. The results were interpreted in terms of the distinctive features concept. It was found that over the course of development, discrimination learning progresses steadily from already formed discriminations of distinctive features, but proceeds slowly, if at all, for those features of graphemes which are not critical.

Trieschmann (1968), using the same forms, found that second- and third-grade retarded readers made more perceptual errors than good readers in the matching task. It should be noted that the control for intelligence in this study was minimal.

In a study using the Gibsons' visual discrimination stimuli (1955) in a matching task, Whipple and Kodman (1969) found that good readers learned the discriminations in fewer trials than retarded readers. In this study, the WISC IQ's of the subjects were from 90 to 115.

The finding that children respond consistently to certain discriminable graphic features and the fact that the ability to do this appears to be related to reading ability is of importance to the present study, in which both graphic and acoustic similarities of letters and numbers were critical features.

Wickelgren has studied adult short-term memory (STM) in terms of the phonemic distinctive features causing intrusion errors. He concluded that a letter or a digit is not encoded as a single element but as a set of internal representatives for the item. When the full set is not encoded in STM, the intrusion of another letter or digit with similar distinctive features results. He has identified four classes of phonemic distinctive features: voicing, nasality, openness, and place. These classes reliably predict intrusion errors in adult subjects and are characteristic of STM in both recall and recognition memory (Wickelgren, 1966a, 1966b).

A Paired Associate Study Comparing Visual, Acoustic, and Semantic Similarity. Gumenik prepared lists of four-letter words in which the stimulus terms of a list were either homonyms, visually similar words, synonyms, or entirely dissimilar control words. Response terms were two-digit numbers. All pairs were presented to adult subjects visually once before recall. More errors were made by the subjects in the acoustic similarity condition than were made by the subjects in the other three conditions. No visual or semantic effects were found. The authors noted that the visual similarity had also not been found in a previous study using auditory presentation. The findings were therefore consistent with the auditory trace hypothesis of STM, i.e. both visual and auditory inputs are stored in auditory form in STM.

The Effect of Shifting to a New Mode of Input. No research was found which related to a shift in second-order input, but a study describing the effect of a modality switch was made by Katz and Deutsch (1963). When a change was made from auditory stimuli to visual stimuli, the subjects were required to press a switch. When the change was in tone or color, the subjects responded in the same way. The results indicated that all subjects were slower to respond to a change of mode than to an intramodal change in tone or color. The retarded readers responded more slowly to a change of mode than did the better readers.

Pilot Study

A preliminary study was carried out using children from three third- and fourth-grade classes in a semi-rural, suburban area very similar to the areas of the schools from which the experimental subjects were selected. The objectives of the pilot work were as follows:

1. To determine the choice of instruments to measure reading ability and intelligence
2. To construct lists with graphic and acoustic cues salient to children
3. To standardize task procedure
4. To estimate task variance

The Gates-MacGinitie Reading Tests, Survey D, Primary CS and Primary C were administered to two third-grade classes and one fourth-grade class. Children selected by their teachers as good and poor readers of average intelligence were tested individually using the Slosson Oral Reading Test (SORT). It was found that the scores of the SORT were comparable to the group-administered test and would serve to screen subjects into high and low reading level (RL) groups. It was also found that for some poorly motivated subjects, individual testing was superior to group testing. Although the SORT does not supply scores for reading speed or comprehension, it appeared to be a valid indicator of the child's reading vocabulary when compared to the Gates in terms of correlations of reading level scores. The mean reading level of Gates scores tended to be somewhat lower than the mean reading level of the same group tested with the SORT.

Slosson reports a reliability coefficient of .99 for a test-retest interval of one week and a correlation coefficient of .96 with the Gray Standardized Oral Reading Paragraphs.

Raven's Coloured Progressive Matrices and the vocabulary subtests of the Wechsler Intelligence Scale for Children (WISC) and the Stanford-Binet Intelligence Scale were administered to individual subjects from the third and fourth grades for comparative purposes. Insufficient variability, partly due to the fact that some of the test words, e.g. "fable," had been the topic of in-class projects, led to the abandonment of vocabulary testing as an estimate of intellectual ability. The choice of Raven's Coloured Progressive Matrices, Forms A, Ab and B was made over other tests for the following reasons: it is language-free in that all test stimuli are in the form of geometric patterned figures; instructions are minimal and the administration time is short; it is not subject to bias due to auditory receptivity; while all test stimuli are visual, it is not a test of visual acuity; it can be adapted for group administration, reducing the time spent in individual sessions.

Birkemeyer (1965) has reported coefficients of .74 for Negro subjects and .70 for white subjects when the Progressive Matrices Test was correlated with the performance scale of the WISC. Correlations with the full scale and the verbal scale were, respectively, .62 and .40 for Negro and .50 and .22 for white subjects.

<u>The Formation of the Acoustic and Graphic Lists</u>. The feasibility of the use of numbers and letters in acoustically and graphically similar pairs was assessed from the responses of 46 children from third- and fourth-grade classrooms. Each child was given a sheet of paper with the numbers from two to nine printed at the top and the letters B, C,

G, F, H, J, K, M, N, Q, R, S, and Z in each of two columns at the left margin and down the center of the page. The center column was in reverse order. The subjects were asked to write the number that looked like each of the letters appearing at the left side of the sheet. When this had been done, they were asked to write the number that sounded like each of the letters in the center column. They were instructed to leave a blank if no number looked or sounded like a given letter, and to use a number more than once if they wished.

The results of this procedure were summarized by finding the proportions of children in each classroom who had selected a number that was the most popular choice of children in that classroom. This summary is presented in Table A-4 of the appendix.

Dominant choices for all letters were the same from the children at the two grade levels with two exceptions: "Z" was most often attributed the sound of "3" by third-grade children, but the sound of "6" by fourth-grade children. The letter "B" was most often attributed the look of "3" by the third-grade children, but the look of "8" by fourth-grade children.

From the 22 different pairs formed by a minimum of 45% of the children in one or both classrooms, 11 pairs were eliminated if the same pair occurred as a dominant choice in both categories of similarity (for example, B-3), or if the letter of the pair was also paired with a different number chosen by a larger proportion of children. Although X was paired with 6 by a smaller proportion of children than was S, it was included in the acoustic list in order to avoid loading the list with numbers which when spelled out began with the letter of the pair. To balance the length of the lists, it was necessary to add "T-1" to the graphic list. The number "one" and "T" had not been included in the selection procedure as it was originally thought that the letter "L" might be read instead of the number "one." In the pilot work and in the experiment this did not prove to be a problem.

The pairs selected for the acoustic list were: F-5, K-8, N-9, X-6, C-3, and Q-2. The pairs in the graphic list were: M-3, G-6, H-4, T-1, S-8, and Z-7. Capital letters were used; "M" had a rounded outline.

When the acoustic and graphic lists were formed, it was felt that such pairs had several advantages. First, they are highly available responses for normal children in the age range studied. Second, single-digit numbers (except 9 and 5) have dissimilar vowel sounds and are not likely to cause errors due to lack of auditory acuity. Third, letters and numbers belong to well-differentiated symbol systems that might be assumed to be cognitively independent. This independence would tend to reduce the familiarization period in which stimulus members are differentiated from response members in the paired associate task. Fourth, no source of bias is introduced tending to favor the high RL subjects, a probable result when words or word-like stimuli are used.

Sixteen children from four third- and fourth-grade classrooms who fulfilled two criteria were selected: one, average intelligence and two, reading ability that was either at grade level or above or at least one year below grade level. The two lists were administered by means of tape recordings or cards bearing printed stimuli. Several methods of presentation of the visual and auditory stimuli were explored. The resultant data indicated that the stimulus lists required from three to approximately 15 repetitions of the six-item lists to reach the criterion of one perfectly correct repetition, an acceptable range of variation in the pilot subjects. The number of items in the tests of recall was increased to provide sufficient variation in scores.

Hypotheses

The hypotheses of the present study follow from the implications of the theories and the related research discussed earlier and from the pilot work. Birch's theory of intersensory integration deficit as it contributes to reading retardation was tested by the comparison of good and poor readers, each receiving the stimulus term of a pair in the visual mode and the response term in the auditory mode. Integration in this paradigm was assumed to be the same as the learning of an association. To test this theory, it was hypothesized that in the visual-auditory (VA) group, high RL subjects learn acoustically and graphically similar pairs in fewer trials than low RL subjects.

Although Gibson says nothing specifically directed toward the relative difficulties of the good or retarded reader, it seemed reasonable to assume that the mastery of the grapheme-phoneme relationship is a legitimate ability variable. Gibson has developed a theory of how graphemes and phonemes are integrated and this can be tested as it applies to good and poor readers by defining the grapheme-phoneme unit as a seen or visualized group of symbols with a phonetic attribute not identical to the phonetic attributes of the symbols taken separately. For this study, the unit equivalent to the grapheme-phoneme unit was the letter-number pair with similar phonetic elements.

It is assumed that there is a basic similarity between the process of word recognition and discovery of the distinctive acoustic or graphic features of the letter-number pairs in this study. The model for both requires a set of prior discriminations. In the case of word recognition, the letters of the alphabet have been discriminated and their phonetic equivalents learned as included in the spoken vocabulary. In the case of the letter-number pair the symbols have previously been differentiated and have labels. In both cases the child's knowledge of language sounds and vocabulary are a prerequisite. In learning the pair, he matches the elements of the letter and number which coincide; in word recognition, he finds one combination of several possible combinations of sounds to match a word in his speaking vocabulary.

The rationale for the second and third hypotheses was based on this model. The visual-acoustic combination of first- and second-order input, the equivalent of the grapheme-phoneme unit, is the mirror-image of the auditory-graphic combination. Both are assumed to represent the same underlying ability factor. It was hypothesized that high RL subjects receiving visual (VV) presentation require fewer trials to learn pairs with acoustic similarity than low RL subjects, and that the same effect holds when subjects in the auditory (AA) mode learn a list with graphic similarity.

The greater saliency of the similarities in the compatible mode-content conditions, VV-graphic and AA-acoustic, let to the prediction of an interaction of mode and content. It was hypothesized that different patterns of response by high and low RL subjects also result in the interaction of reading level, mode and content. It was reasoned that if the AA-acoustic and VV-graphic combinations do not differentiate high and low RL subjects while the AA-graphic and VV-acoustic combinations differentiate the two groups, a different pattern of response results in a triple interaction.

As a result of the decision to use acoustic items and graphic items in two separate lists as repeated measures, an order factor was included in the design. It was observed during pilot work that the effect of list presentation was not the same for the two orders. The last three hypotheses dealt with this variable. It was hypothesized that the learning rate of low RL subjects is affected by the order of list presentation, while high RL subjects adapt to a shift in critical features.

The hypotheses are summarized below. All are stated in terms of trials to criterion. By testing the subjects for backward recall (the recall of the stimulus term when presented with the response term alone) it was planned to apply the same hypotheses to that dependent variable.

1. When stimulus terms are presented visually and response terms are presented auditorially, the high RL subjects learn paired associates with acoustic or graphic similarity in fewer trials than low RL subjects. $(VA_{High} < VA_{Low})$

2. An interaction exists between mode of presentation and type of list similarity. $(V_{Ac} > V_{Gr};\ A_{Gr} > A_{Ac})$

3. An interaction exists between RL, mode, and type of list. $(V_{Ac_{Low}} - V_{Gr_{Low}} > V_{Ac_{High}} - V_{Gr_{High}};\ A_{Ac_{Low}} - A_{Gr_{Low}} > A_{Ac_{High}} - A_{Gr_{High}};$ $VA_{Ac_{Low}} - VA_{Gr_{Low}} > VA_{Ac_{High}} - VA_{Gr_{High}})$

4. When presentation is strictly auditory, high RL subjects learn paired associates with graphic similarities in fewer trials than low RL subjects. $(AA_{Gr_{High}} < AA_{Gr_{Low}})$

5. When presentation is strictly visual, high RL subjects learn paired associates with acoustic similarities in fewer trials than lower RL subjects. $(VVA_{c_{High}} < VVA_{c_{Low}})$

6. An interaction exists between RL and order of presentation. $(O1_{High} - O2_{High} < O1_{Low} - O2_{Low})$

7. When a list of acoustically similar pairs is learned first (Order 1), low RL subjects do not learn at the same rate as when it is presented after learning a list with graphically similar pairs (Order 2), while the performance of high RL subjects is

unaffected by the order in which the lists are learned. ($O_{1Ac_{Low}} \neq O_{2Ac_{Low}}$; $O_{1AcHigh} = O_{2AcHigh}$)

8. When a list of graphically similar pairs is learned first, low RL subjects do not learn at the same rate as when the list is presented after learning a list with acoustically similar pairs, while the performance of high RL subjects is unaffected by the order in which the lists are learned. ($O_{1Gr_{Low}} \neq O_{2Gr_{Low}}$; $O_{1Gr_{High}} = O_{2Gr_{High}}$)

CHAPTER III - METHOD

Subjects

The subjects were 72 males, chosen from third- and fourth-grade classes in three schools in towns in semi-rural suburban areas near East Lansing. All schools were characterized as drawing pupils from white, lower-middle to upper-middle socio-economic backgrounds.

Intelligence

Subjects who had scored between 90 and 110 on one of three standardized group tests of intelligence or had been retested with the WISC or the Stanford-Binet and found to score within this range were selected. After this preliminary selection, the experimenter administered the Raven Coloured Progressive Matrices Test, Forms A, Ab and B to all subjects. Slides were made from the test booklet and projected on a screen by a Kodak Carousel projector. The subjects were tested in groups of approximately 12. In all, 48 subjects were tested in group sessions prior to the experimental sessions and 24 subjects were tested individually immediately following the experimental procedure.

Reading Level

With the help of the classroom teacher and the remedial reading specialist, subjects were selected who were reading at a level at least one year below the level of the rest of his class. Since scores from standardized reading tests had been obtained for most subjects six or more months prior to the time of experimentation, it was necessary to administer the Slosson Oral Reading Test to each subject immediately following the experimental procedure in order to obtain an estimate of reading level. At the time of testing, subjects were in the eighth and ninth months of the school year.

From each classroom which contributed one or more retarded readers, an equivalent number of subjects who met the criteria of average or better reading ability plus intellectual ability in the 90-110 range were selected.

The subjects were assigned to groups randomly on arrival at the experimental setting. The experimenter was unaware of the reading level of the individual subjects when they arrived for the experimental sessions, since the reading test followed the experimental procedure. However, after all six subjects in the high or low RL group of the six experimental conditions had been tested, it was no longer possible to avoid prior knowledge of the reading level of the subject being tested.

<u>Task</u>

<u>Lists</u>. The paired associate lists employed evolved from prior investigation of the choices of third- and fourth-grade children who had been asked to select numbers which either looked like or sounded like single-digit numbers. The acoustic list (letters and numbers with similar acoustic features) contained the pairs X-6, K-8, N-9, Q-2, C-3, and F-5. The graphic list (letters and numbers with similar attributes of conformation) contained the pairs H-4, T-1, S-8, G-6, Z-7, and M-3.

<u>Apparatus</u>. The pairs were presented on a Lafayette memory drum for the VV presentation, a Norelco 150 cassette tape recorder for the AA presentation, and both devices in the VA presentation. The memory drum was activated by a hand-held switch and the tape recorder was

controlled by a foot pedal. In the VA condition, the memory drum was activated by the experimenter when a recorded signal was heard. The visual presentation of the stimulus letters in the VA mode was closely synchronized with the auditory presentation of the response numbers.

Pronunciation of the stimuli on tape was done by the experimenter. In the VV presentation, letters and numbers were printed in black ink on a white background with the use of a lettering guide and were ½" high, exposed by openings in the memory drum 4" apart. In the VA condition, the subjects saw the same letters but the numbers were hidden.

To prevent serial learning, the six items of each list were presented in scrambled orders. A sequence of eight randomly ordered versions of each list was repeated once if necessary, to a maximum of 16 repetitions of the list. One complete cycle of the six pairs constituted a repetition.

Presentation trials. All subjects received the same tape-recorded instructions, as follows: "Today you are going to learn a sort of code. One way to write words in code is to give every letter in the words a number. Then you can send just the numbers to someone who knows the code and he could put the right letters with the numbers to read your message. Today you are going to learn numbers for just a few letters in the alphabet to see if you get the idea of coding. You will hear/see a letter and at the same time you will hear/see the number that is the code number for that letter. Listen/watch for the number that goes with the letter, and try to remember the letters and numbers that go together."

In the VV presentation, the subject saw a letter-number pair exposed simultaneously in separate openings of the memory drum for 2 seconds followed by a 2-second interval when the slide openings were closed.

The AA group heard the letter at the onset of the 2-second period and heard the number immediately following the letter. The sequential presentation of the letter-number pair occurred within a 1-second interval. The VA subjects saw the letter in the slide opening and simultaneously heard the number. The letter remained exposed for 2 seconds as in the VV presentation. The presentation list was shown once.

Acquisition. The anticipation trials were preceded by the following instructions: "That was the list of letters and numbers you will learn now. This is how you will learn them: you will hear/see each letter again. As soon as you hear/see the letter, say the number that you think goes with it. Then you will hear/see the letter again and you will hear/see the number that goes with it to tell you if you were right. When you hear/see a letter you can't remember the number for, say 'Blank.' Ready?" The presentation of each pair began with the 2-second exposure of the stimulus letter for the VV and VA conditions or the sound of the stimulus letter via the tape recorder for the AA condition. A 2-second interval followed, and the subject's response was recorded by the experimenter if it occurred before the presentation of the S-R pair. A 2-second inter-pair interval was used. Thus, a total of 8 seconds was required for complete presentation of each S-R pair.

If the subject did not respond to at least one of the stimuli in the first six anticipation trials, the instructions were briefly repeated. Anticipation trials were continued until all six response terms for one of the eight random arrangements of the list were correctly given, or a maximum of 16 repeated presentations of the list had been made. The criterion was the number of repetitions of the list required by the subject to respond correctly to all six items successively.

Backward Recall Tests. Immediately following the learning trials the subject was given a test of backward recall. A 5" x 6" card with the numbers of the pairs printed ½" high in black ink, was given to the subject with the instructions to say the letters that went with those numbers in the order given. Recall was untimed, but if the subject did not respond to a number before 10 seconds had passed, the experimenter said, "Next one." Incorrect responses and omissions were counted as errors.

Mixed List Backward Recall Test. Following the backward recall of the second list, the subject was given a card containing the response term numbers from both lists, distributed in the same way as in the backward recall test for the separate lists. Each number occurred three times, but because three response terms were common to both lists, there were only 27 test items, nine from the acoustic list, nine from the graphic list, and nine common to both lists. The subject was told that the letter from either list was correct for the numbers that were common to both lists.

The Slosson Oral Reading Test was administered after the mixed list backward recall test, and if the subject had not been included in the group testing session, the booklet form of the Raven CPM was administered. Finally, in the time remaining, the subject was asked, "How did you remember that (stimulus letter) and (response number) went together? Did anything help you to remember (S-R pair)?" Each subject was questioned about two pairs from each list.

CHAPTER IV - RESULTS

The results of the administration of the Slosson Oral Reading Test yielded a difference in the means of the high and low RL groups of approximately two and one-half years. The results are presented in Table 1.

TABLE 1

Means, Standard Deviations and Ranges of Scores of the High and Low Reading Level Groups for the Slosson Oral Reading Test

Group	$\bar{X}$	S.D.	Range
High Reading Level	5.53	1.00	4.20-7.50
Low Reading Level	2.95	0.40	1.70-3.50

In order to determine whether the analysis of covariance was appropriate, the dependent variables and the scores for Raven's Progressive Matrices Test were correlated using the Pearson product-moment correlation. The correlations obtained for the total sample and for the two separate RL groups ranged from -.15 to .11, none of which were significant at the .05 level.

The comparison of the means for the high and low RL groups showed that they did not differ in intellectual ability as measured by Raven's Progressive Matrices Test. These data are presented in Table 2. A comparison of the means for the groups receiving group or individual administration of the test showed that there was no significant difference between them. The reliability of the test as estimated by the Kuder-Richardson #20 formula and the standard error of measurement are also given in Table 2.

TABLE 2

Summary of Statistics Based on Raw Scores of the High and Low Reading Level Groups, Groups Receiving Individual or Group Test Administration, and the Total Group on Raven's Progressive Matrices Test

Group	n	$\bar{X}$	S.D.	Range	K.R.#20	$S.E._{meas.}$
High Reading Level	36	26.58	5.01	15-34	-	-
Low Reading Level	36	26.14	3.59	18-33	-	-
Group Admin.	48	26.23	4.90	15-34	.84	1.94
Individual Admin.	24	26.71	3.15	21-33	.65	1.86
Total	72	26.36	4.34	15-34	.84	1.94

Learning Trials

The total number of repetitions of each list needed by a subject to reach the correct anticipation of all six items consecutively is referred to in the following pages as "number of trials."

The means and standard deviations of the dependent variable for each of the 12 groups of subjects are shown in Table A-1 of the appendix.

The data for the learning trials were analyzed by a fixed analysis of variance design in which the two lists were repeated measures crossed with the factors of reading level, mode, and order. The results of the analysis are summarized in Table 3. This analysis yielded significant

TABLE 3

Analysis of Variance of the
Number of Trials to Criterion

Source	Sum of Squares	df	Mean Square	F	p
Reading Level (R)	150.06	1	150.06	10.12	<.01
Mode (M)	79.26	2	39.63	2.67	<.10
R x M	31.79	2	15.90	1.07	
Order (O)	39.06	1	39.06	2.63	>.10
R x O	95.06	1	95.06	6.41	<.05
M x O	111.12	2	55.56	3.75	<.05
R x M x O	39.04	2	19.52	1.32	
Ss within groups	889.58	60	14.83		
Lists (L)	22.56	1	22.56	2.57	>.10
R x L	4.34	1	4.34		
M x L	118.04	2	59.02	6.72	<.01
R x M x L	14.35	2	7.17		
O x L	6.67	1	6.67		
R x O x L	0.56	1	0.56		
M x O x L	0.68	2	0.34		
R x M x O x L	18.04	2	9.02		
L x Ss within groups	547.25	60	8.79		

effects due to reading level, F (1,60) = 10.12, $p < .01$, the Reading Level X Order interaction, F (1, 60) = 6.41, $p < .05$, the Mode X Order interaction, F (2, 60) = 3.75, $p < .05$, and the Mode X List interaction, F (2, 60) = 6.72, $p < .01$. The main effects for mode, order and list were not significant, as well as the other six interactions containing the reading level factor and the Order X List interaction. The expected Reading Level X Mode X List interaction did not yield an F significant at the .05 level.

The difference in the mean number of trials of the high and low RL groups receiving the crossmodal VA presentation was also not significant, thus not supporting the crossmodal deficit hypothesis.

Tests of simple effects were performed using Dunn's multiple comparison procedure (Kirk, 1968), in order to determine the extent to which the remaining specific hypotheses were supported. Dunn's technique yields d values for each set of comparisons examined, dividing the level of significance evenly among the comparisons made.

The mean number of trials to learn the acoustic list in the visual mode was 7.17 for the high RL subjects and 11.58 for the low RL subjects, a difference of 4.41 trials, confirming the hypothesis in the direction predicted, d = 3.22, $p < .05$. The difference in the mean number of trials of the high and low RL groups learning the graphic list in the AA presentation was not significant. The expected effect of the two incompatible combinations, VV-acoustic and AA-graphic, was not found in the AA-graphic combination, offering only partial support for the hypothesis of high RL group superiority in making difficult integrations of first- and second-order input.

The tests of the hypotheses concerning the interference due to list order were performed using Dunn's technique. The results supported the hypothesis that the effect of order of presentation was not the same for the two groups as shown in Figure 1. The simple effects for the two RL groups were opposite to those predicted. For the low RL subjects, the difference in the trials to criterion on neither the graphic list nor the acoustic list was significant, revealing no order effect in the low RL groups. The difference in trials to criterion on the graphic list by high RL subjects in the two orders was 3.22, $\underline{d} = 2.62$, $\underline{p} < .05$. The high RL group learning the acoustic list first required fewer trials ($\bar{X} = 4.78$) than the group learning the graphic list first ($\bar{X} = 8.00$). The difference in trials to criterion for high RL subjects to learn the acoustic list in each order was not significant.

<u>Post hoc</u> comparisons were performed using Tukey's ratio. In this test the critical value $\underline{q}$ is based on the maximum number of steps in an ordered set of means (Winer, 1962). The ratio was applied to test meaningful pairwise comparisons where significant interactions existed. The dependency of order on reading level was explained by the comparison of the means of trials required to learn both lists. For high RL subjects, Order 1 (the acoustic list first) required fewer trials than Order 2, $\underline{q}\ (2, 60) = 2.93$, $\underline{p} < .05$. The Order 1 high RL subjects required fewer trials than the Order 2 low RL subjects, $\underline{q}\ (2, 60) = 3.67$, $\underline{p} < .01$, as indicated in Table 4.

The effect of mode was dependent upon both lists and order of lists. When the rate of learning the two lists was compared in each of the three modality groups, it was found that only in the VV mode was there a significant difference between lists. The VV treatment groups needed

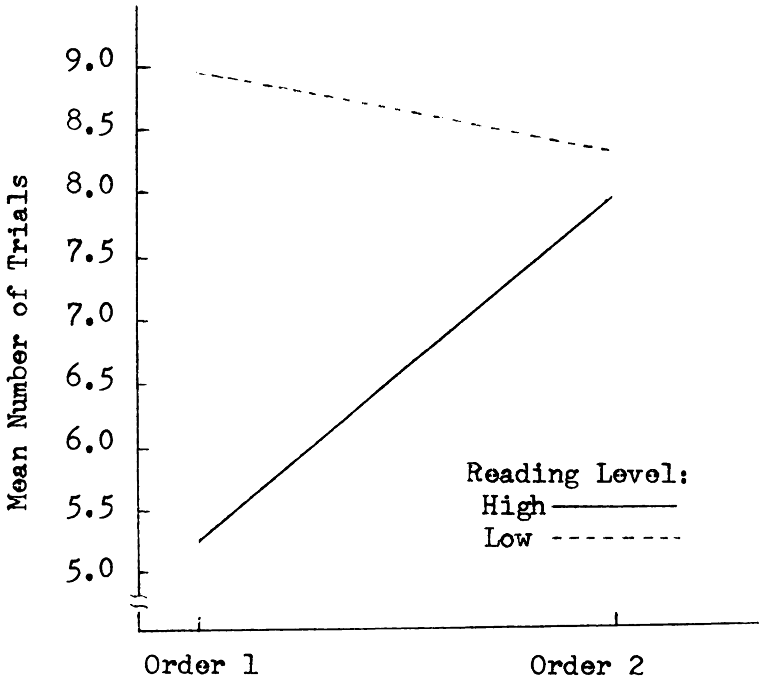

Figure 1: Mean Number of Trials to Learn Both Lists by Order 1 (Acoustic List First) and Order 2 (Graphic List First) Subgroups of the High and Low Reading Level Groups

TABLE 4

Mean Number of Trials to Learn Both Lists
by High and Low RL Ss in Each Order

Reading Level	Order 1		Order 2	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
High Reading Level	5.28	2.37	7.94	4.38
Low Reading Level	8.94	3.99	8.36	3.44

more trials to learn the acoustic list and fewer to learn the graphic list, $\underline{q}$ (2, 60) = 5.53, $\underline{p}<.01$. These data are presented in Table 5 and plotted in Figure 2.

TABLE 5

Mean Number of Trials to Learn Each List by Each Modality
Group

Mode	Acoustic List		Graphic List	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Auditory (AA)	8.12	4.00	8.87	4.03
Visual (VV)	9.37	4.44	6.04	3.20
Visual-Auditory (VA)	6.58	2.96	6.79	3.59

The subjects in the AA group required more trials to learn the graphic list than subjects in the VV, but not the VA groups, $\underline{q}'$ (3,60) = 4.04, $\underline{p} <.05$. The subjects in the VV group required more

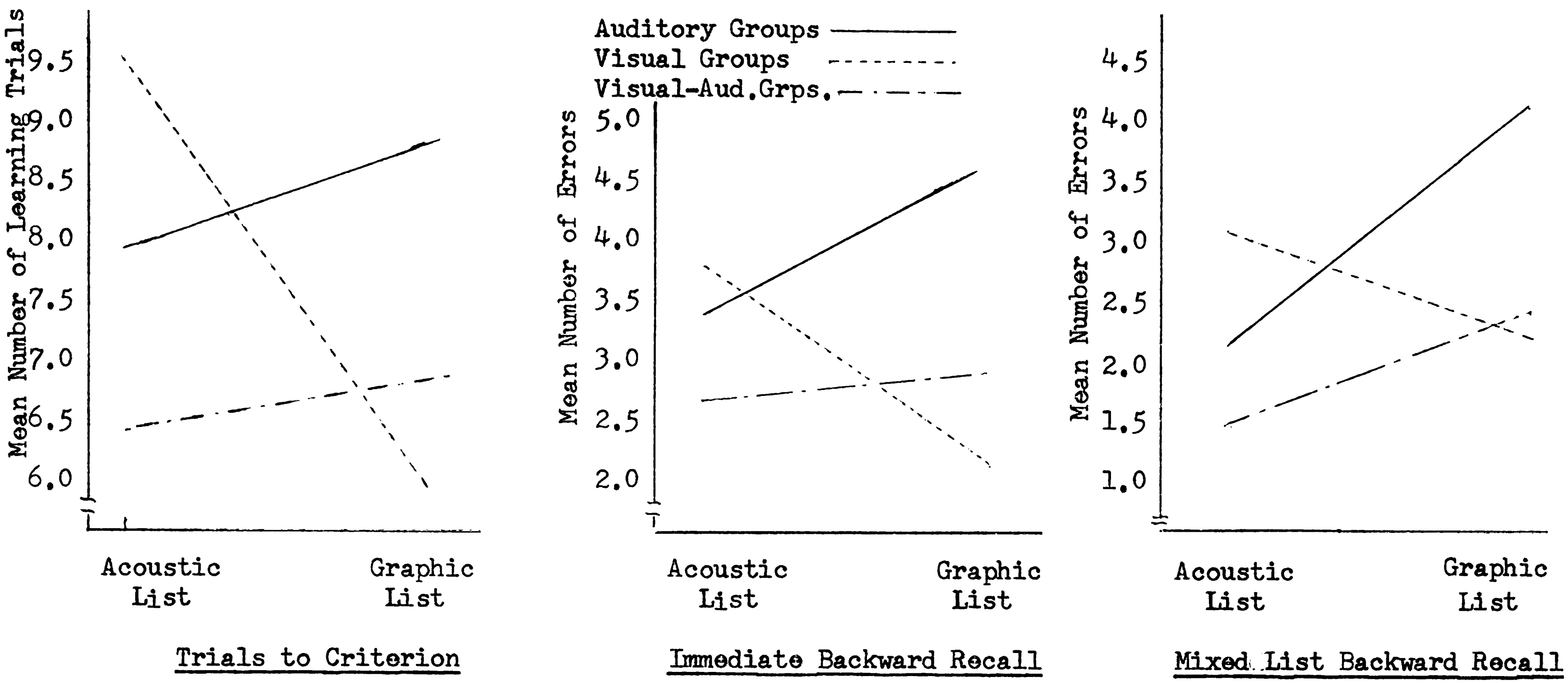

Figure 2: Interactions of Mode and List in Learning, Immediate Backward Recall of Individual Lists, and Mixed List Backward Recall.

trials to learn the acoustic list than subjects in the VA group, but not the AA group, q' (3, 60) = 3.98.* Thus, for acoustic list learning, performance was not significantly different for the AA and VV groups. For graphic list learning, performance was not significantly different for the VV and VA groups.

When the Mode X Order interaction was analyzed, it was found that the difference due to order was not significant for the VV and VA groups, but the AA groups learning the graphic list first required more trials to learn the lists than the AA groups learning the acoustic list first, q (2, 60) = 3.15, $p < .05$. These data are presented in Table 6 and plotted in Figure 3.

TABLE 6

Mean Number of Trials to Learn Both Lists in Each Order by Each Modality Group

Mode	Order 1		Order 2	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Auditory	6.75	3.71	10.25	3.52
Visual	7.96	4.19	7.46	3.55
Visual-auditory	6.62	2.79	6.75	3.71

An additional analysis of variance using the same design and dependent variables but with the list factor expressed by first list or second list rather than acoustic list or graphic list, yielded a significant

*Use of the q' symbol indicates that a pooled mean square error term was used.

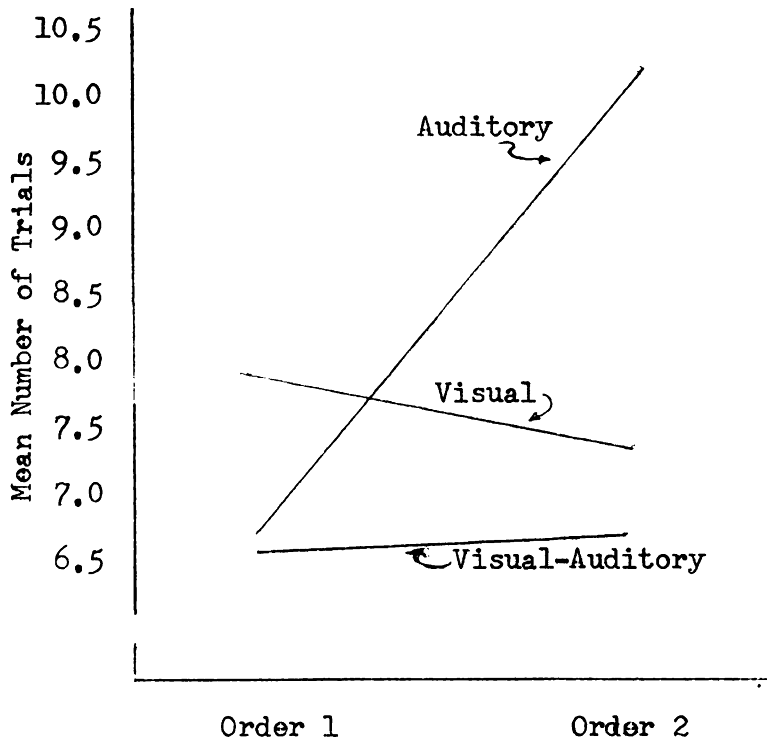

Figure 3: Mean Number of Trials to Learn Lists by Order 1 (Acoustic List First) and Order 2 (Graphic List First) Subgroups of the Three Modality Groups

Mode X Order X List interaction, $\underline{F}$ (2, 60) = 6.72, $\underline{p} < .01$. The graph for this interaction is presented in Figure 4.

Immediate Backward Recall Tests

Although the low RL groups receiving the VA presentation made more errors across orders and lists than were made by the high RL VA group, the difference was not significant, again failing to support the crossmodal deficit hypothesis. The tests of the specific hypotheses using Dunn's procedure also failed to show a difference between high and low RL groups in regard to the effect of order of list.

An analysis of variance, summarized in Table 7, of the same design as that used for analysis of learning trials, was used to analyze the data of the backward recall tests administered after each list was learned. No main effects or interactions were significant, although the Reading Level X Order X Mode interaction approached significance, $\underline{F}$ (2, 60) = 2.48, $\underline{p} < .10$. The Mode X List interaction was in general similar to the Mode X List interaction for learning trials, as shown by Figure 2.

Comparison of the results of this analysis with those of the learning trials showed that an increase in error variance was accompanied by a decrease in the range of group means, resulting in the nonsignificant effects.

The high and low RL subjects, given the response terms as probes, recalled the stimulus terms equally well. It was believed that the procedure used in acquisition could have produced this effect, masking a true difference in the RL groups. The subjects who learned the pairs slowly were repeatedly exposed to the pairs they had already learned. Thus, the slow learner had an opportunity to overlearn the pairs he

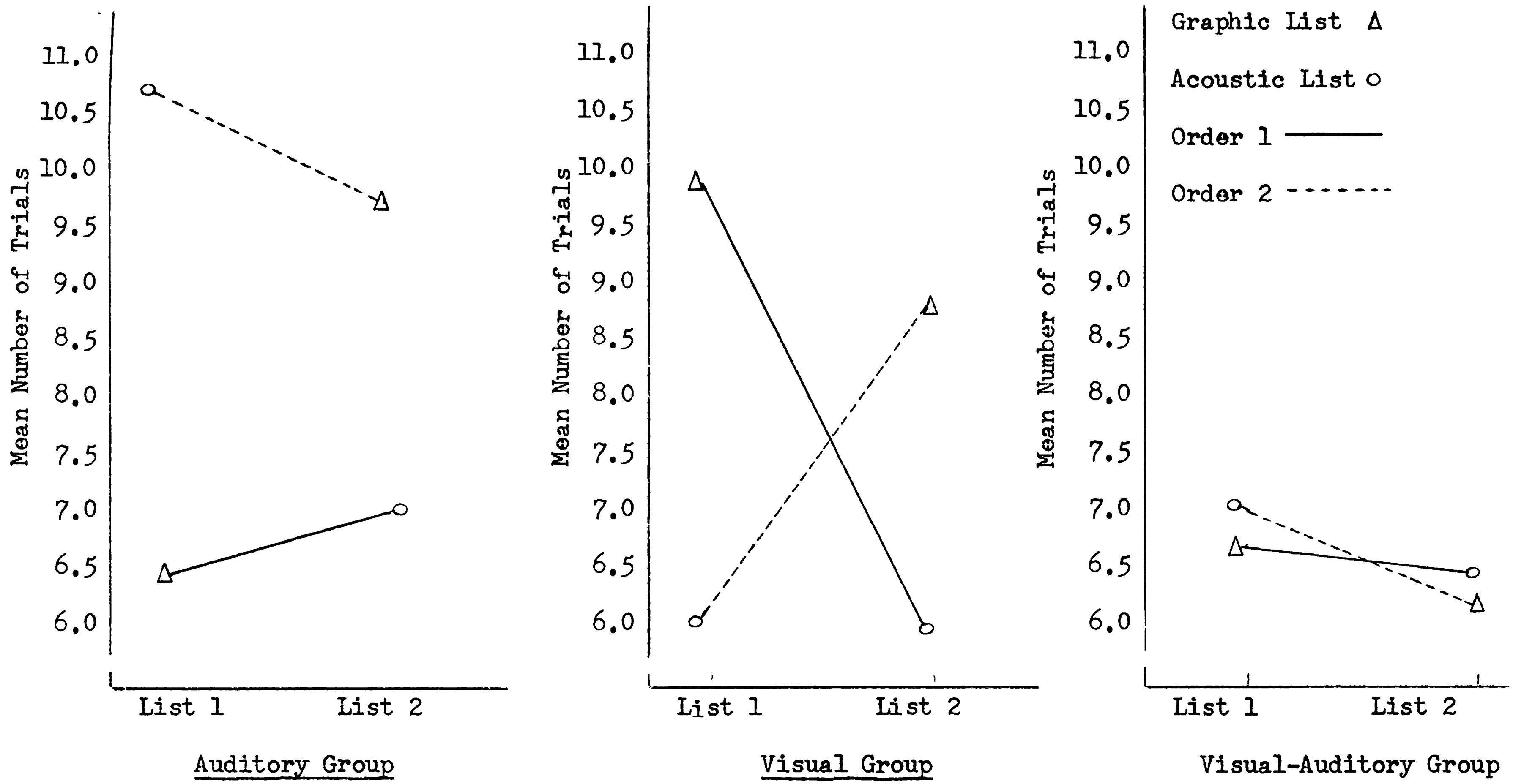

Figure 4: Mean Number of Trials to Learn First and Second List Presented (Acoustic or Graphic) for Order 1 and Order 2 Groups in Each Modality

TABLE 7

Analysis of Variance of Errors on Immediate Backward Recall Tests

Source	Sum of Squares	df	Mean Square	F	p
Reading Level (R)	24.17	1	24.17	1.49	
Mode (M)	40.26	2	20.13	1.24	
R x M	18.01	2	9.01		
Order (O)	21.01	1	21.01	1.29	
R x O	10.56	1	10.56		
M x O	10.68	2	5.34		
R x M x O	80.54	2	40.27	2.48	<.10
Ss within groups	975.42	60	16.26		
Lists (L)	0.06	1	0.06		
R x L	0.06	1	0.06		
M x L	47.37	2	23.69	2.45	<.10
R x M x L	10.79	2	5.40		
O x L	0.01	1	0.01		
R x O x L	3.67	1	3.67		
M x O x L	2.51	2	1.26		
R x M x O x L	0.93	2	0.47		
L x Ss within groups	581.08	60	9.68		

had mastered, while the subjects who learned the list quickly may have seen the pairs as few as three times before being tested. It was decided to examine the data for evidence that subjects reaching criterion in more trials may have tended to make relatively fewer errors on the tests of backward recall. Product-moment correlations were calculated for all possible pairs of dependent variables as shown in Table 8. The substantial coefficients were all positive and no general tendency for the effect in question was evident.

Mixed List Backward Recall Test

The specific hypothesis regarding a crossmodal deficit was again tested and found to be nonsignificant. The hypotheses regarding the superiority of the high RL AA group in recall of the graphic list and the high RL VV group in the recall of the acoustic list showed that these groups again did not differ from the low RL subjects.

The tests of hypotheses concerning the effect of order of presentation in learning showed that order affected the recall of the graphic list for both high and low RL subjects. List order also affected the recall of the acoustic list for low RL subjects. The difference in the mean errors for each order for high RL subjects in recall of the graphic list was 3.33, $\underline{d}' = 2.46$, $p < .01$. The difference in the mean errors in each order for low RL subjects in recalling the graphic list was 2.05, $\underline{d}' = 1.93$, $p < .05$. The difference in the mean errors for each order for low RL subjects in recalling the acoustic list was 2.00, $\underline{d}' = 1.93$, $\underline{p} < .05$.

The effect of order in the high RL group appeared to carry over from the learning of the graphic list to the recall of the graphic

TABLE 8

Summary of Simple Correlations Between All Pairs
of Dependent Variables (N = 72)

	GT	A-BR	G-BR	A-MBR	G-MBR	AG-MBR
Acoustic Trials (A-T)	.35	.48	.42	.29	.40	.43
Graphic Trials (G-T)		.23	.51	-.15	.53	.28
Acoustic Backward Recall (A-BR)			.29	.45	.27	.59
Graphic Backward Recall (G-BR)				-.01	.62	.52
Acoustic Mixed Backward Recall (A-MBR)					-.01	.26
Graphic Mixed Backward Recall (G-MBR)						.47
Acoustic-Graphic Choice, Mixed Backward Recall (AG-MBR)						

list for the Order 2 (graphic list first) group. The greater number of learning trials for the low RL subjects on both lists appeared to result from the fact that there was forgetting of the first list learned, regardless of the type of list item.

A third analysis of variance, summarized in Table 9, used the same design as the previous analyses but contained three levels for the lists factor. These were: items with response terms from the acoustic list; items with response terms from the graphic list; and items with identical response terms from both lists. The analysis yielded significant effects due to mode, $\underline{F} = 3.21$, $\underline{p} < .05$; the Mode x List interaction, $\underline{F} = 2.49$, $\underline{p} < .05$; and the Order X List interaction, $\underline{F} = 15.11$, $\underline{p} < .01$.

The relevant post hoc comparisons for simple effects were made using Tukey's ratio. The recall of the Order 2 groups was better for the acoustic list than for the graphic list, $\underline{q}$ (3, 120) = 7.58, $\underline{p} < .01$, and the items which shared response terms from both lists, $\underline{q}$ (3, 120) = 4.97, $\underline{p} < .01$.

As expected, the Order 1 (acoustic list first) groups recalled the graphic list items with fewer errors than did the Order 2 groups, $\underline{q}'$ (2, 60) = 6.39, $\underline{p} < .01$, and the Order 2 groups recalled the acoustic items with fewer errors than did the Order 1 groups, $\underline{q}'$ (2, 60) = 3.03, $\underline{p} < .05$. The items with response terms from both lists were not recalled differentially by the Order 1 and 2 groups. The interaction of order and list is presented in Figure 5.

An analysis of the Mode X List interaction showed that only in the AA groups was there a significant difference in mean errors in items recalled from the two lists. Recall of the acoustic list was

TABLE 9

Analysis of Variance of
Errors on Mixed Backward Recall Test

Source	Sum of Squares	df	Mean Square	F	p
Reading Level (R)	26.04	1	26.04	2.71	>.10
Mode (M)	61.44	2	30.72	3.21	<.05
R x M	18.78	2	9.29		
Order (O)	19.56	1	19.56		
R x O	13.00	1	13.00		
M x O	4.70	2	2.35		
R x M x O	52.48	2	26.24	2.74	>.10
Ss within groups	574.94	60	9.58		
Lists (L)	24.53	2	12.26	2.59	<.10
R x L	8.69	2	4.35		
M x L	47.28	4	11.82	2.49	<.05
R x M x L	1.94	4	9.49		
O x L	143.23	2	71.62	15.11	<.01
R x O x L	3.95	2	1.98		
M x O x L	3.30	4	0.82		
R x M x O x L.	11.85	4	2.96		
L x Ss within groups	569.22	120	4.74		

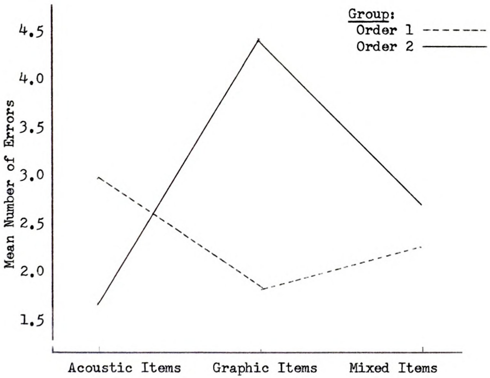

Figure 5: Mean Number of Errors on the Mixed List Backward Recall Test for Order 1 and Order 2 Groups. Items Are: Response Terms from the Acoustic List, the Graphic List, or Items from Both Lists.

superior to recall of the graphic list by subjects in the AA group, $q\ (3, 120) = 4.49$, $p < .01$. These data are presented in Figure 6.

When comparisons between modality groups were made, the recall of the graphic list by the AA group was inferior to that of the VV and the VA groups, $q'\ (3,120) = 3.39$, $p < .05$, and $q'\ (3, 120) = 3.64$, $p < .05$.

Comparing the results of the three analyses for learning trials and backward recall, it can be seen that the level of superiority found for learning trials in the high RL group was not maintained in the immediate backward recall tests. In the mixed backward recall test, the high RL group was superior to the low RL group only in the recall of items from the list that had been learned first, whether it was acoustic or graphic.

Post-experimental Quiz

Data from the brief post-experimental quiz was summarized in order to learn to what extent the acoustic and graphic features of the pairs had been observed and used by the subjects as an aid to memory. When the chi-square test of independence was applied to the answers of the 64 subjects who had been questioned, the difference in the replies of the two RL groups was not significant at the .05 level. Seven subjects in the low RL group and nine in the high RL group were unable to verbalize a way in which they linked the pairs. Of the 25 high RL subjects and 23 low RL subjects who did verbalize an attribute which helped them, 24 in the high RL group and 22 in the low RL group mentioned an acoustic or graphic similarity as an aid. Almost no attributes of non-perceptual features were mentioned. The statements of eight subjects indicated that they had remembered certain pairs as if the

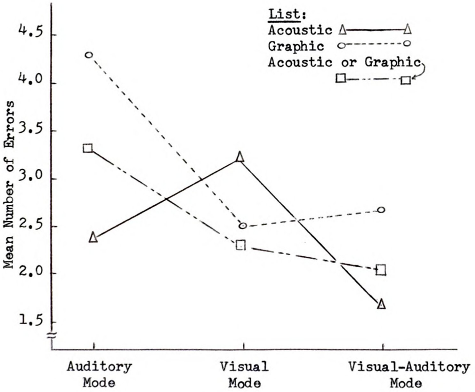

Figure 6: Mean Number of Errors on the Mixed List Backward Recall Test for the Three Modality Groups. Items were: Response Terms from the Acoustic List, the Graphic List, or Both Acoustic and Graphic Lists.

number of the pair indicated the place of the letter of the pair in an ordered list, i.e. C was the third letter in the alphabet.

It appeared that most subjects discovered some of the acoustic and graphic features during the learning trials. There was no evidence from the subjects' replies to indicate that any pair except C-3 had unforeseen features which would make it easier to retain for some subjects.

CHAPTER V - DISCUSSION AND CONCLUSIONS

Trials to Criterion

Hypothesis 1. There was no support for the prediction that the association of non-redundant stimuli, each presented in a different mode, is learned more slowly or retained less well by retarded readers compared to better readers. Therefore, the intersensory integration deficit theory as stated by Birch was not supported. In contrast to the VV and AA presentations, the VA presentation appeared to minimize the disturbance of learning and recall patterns created by the factors of list and list order for high and low RL subjects alike.

Hypotheses 2 and 3. The presence of an interaction between mode of presentation and the second-order input of the lists was found as expected, but the response patterns of the high and low RL groups were very similar. Apart from the effect of lists on the VA groups, the VV and AA group means showed that the relative difficulty of learning in a given modality was dependent upon the list being learned, even though the lists were learned in approximately the same number of trials across modes. The design of the experiment was therefore successful in showing that children are sensitive to variation of both first- and second-order input of the type employed.

Hypotheses 4 and 5. In contrast to Birch's statement of integration deficit, the effect of mode and the critical features of each list for each of the RL groups was hypothesized. It was shown that for the VV presentation of the acoustic list, high RL subjects were superior to the low RL subjects, as expected. The expectation that the incompatibility of mode and content in general would prove more detrimental to the learning of the low RL subjects was not supported, since the learning rate of high and low RL subjects was not different when presentation was auditory and the list pairs had graphic similarity.

Whatever it is that makes the formation and mastery of the grapheme-phoneme unit easier for the high RL subject, as inferred from his high reading achievement, also appears to operate in the learning of letter-number pairs with acoustic critical features in the visual mode. When pairs with graphic similarities are presented auditorially, the similarity may be discoverable only through visual imagery. Because the AA-graphic condition did not differentiate high and low RL groups, no relationship of visual imagery to reading achievement is suggested by the data.

Across and within modality groups, performance on the graphic list did not differentiate high and low RL groups. This finding is of interest in regard to the issue of the relative importance of graphic and acoustic cues. The data indicate that by the time an individual is eight or nine years of age, sensitivity to graphic cues no longer differentiate the good and poor reader.

The data from the post-experimental interview indicated that subject awareness of the critical features was greater for the graphic rather than the acoustic pairs and that there was no difference between high and low RL subjects in their awareness of graphic or acoustic features.

Hypotheses 6, 7 and 8. As predicted, reading level interacted with order of list, but the difference between the RL groups was opposite to the expected effect. It was hypothesized that low RL subjects would be more sensitive to the effect of a shift in the critical features of the pairs. Instead the high RL subjects proved to respond differentially to the change, requiring more trials to learn the lists when the graphic list was presented first. To explain the fact that the means for the low RL group did not reveal sensitivity to order, it is possible to assume that the low RL subjects may have adopted a strategy of simple repetition or rote learning. Such a strategy is equally appropriate to either list, while a strategy to look for either graphic or acoustic features in both lists would be detrimental to the acquisition of the second list. However, such an assumption is misleading, as inspection of the means of Order 1 and Order 2 groups in each RL group and in each modality group reveals. The subjects in the AA condition receiving the graphic list first needed more trials to learn the graphic list, regardless of RL, than they needed to learn the same list in other conditions. Moreover, the reduction or increase in the number of trials needed to learn the second list, acoustic or graphic, was not significant for either RL group when modes were combined. Thus there is no reason to suspect that learning by rote was more frequent among low RL subjects. The sensitivity of high RL subjects to order as shown by the interaction of RL and order may reflect chiefly the tendency of the high RL subjects in the AA condition to rely on visual imagery in the search for graphic cues in the acoustic list after such a strategy was successful with the first-learned, graphic list.

The Interaction of Mode with Lists and Order of Lists. Although the three modality groups did not differ across all other factors, an interaction with order led to the finding that the performance of the AA groups was adversely affected by the learning of the graphic list first rather than second. Both the VV and VA conditions were relatively resistant to the effects of order.

The relationship of the VA condition to the two single-modal conditions is most easily grasped in terms of the Mode x List x Order interaction presented in Figure 4. The resistance of the VA subjects to the effects of interference from either list, regardless of list order, is surprising. In the AA condition, carryover effects are apparent in the learning of the acoustic list, but the learning of the graphic list appears to have been slightly facilitated by the prior learning of the acoustic list. In the VV condition, carryover effects were not observed. Regardless of order, the acoustic list was learned slowly and the graphic list rapidly. In the VA condition, neither list nor order appeared to affect the acquisition of the pairs to a significant degree.

The reason for the superiority of the VA condition is difficult to explain and is counter to the results of studies in which single-modal and multi-modal presentation is compared (Van Mondfrans and Travers, 1965). In the present task, procedure demanded that the subject respond vocally with the response term. It is likely that the S-R terms were rehearsed sub-vocally as a unit and unlikely that the response term alone entered auditory process.

The visual stimulus term remained exposed for 2 seconds. It is probable that during the same interval the response term was visualized with it. Some evidence supports the hypothesis that children make use of visual imagery in the learning of paired associates (Paivio, 1966). In the 2-second interval between the presentation trial and the anticipation trial, the auditory processing may have taken place. Thus, the VA pairs may have been processed both visually and auditorially, and it would be expected that under these conditions the difference between lists would be minimized.

Backward Recall

Immediate Backward Recall Tests. When tested for backward recall immediately following one correct anticipation of all six items of a list, the effects found in the analysis of trials to criterion were not parallel to the backward recall effects. These effects were still present, as found by inspection of the rank order of means for main effects in learning, immediate backward recall, and mixed lists backward recall.

The positive correlations which were obtained between acoustic list dependent variables and graphic list dependent variables indicated that subjects who learned a list slowly tended to make more errors during recall. The correlations were not high, however, and it was not surprising to find that there was no difference between the number of errors in the VV-acoustic condition made by the high and low RL subjects in the backward recall items.

Mixed Lists Backward Recall. The recall of items from both lists was strongly influenced by the list learned last. The interference was common to both RL groups, although it was not evident in the recall of first-learned acoustic items by the high RL subjects.

The facilitative effect of the AA-acoustic combination was present in backward recall as it was in learning. The lack of a difference between recall of graphic and acoustic items in the VV and VA groups suggested that the VV presentation may have had an advantage over the AA presentation.

A large proportion of the variance contributing to the significance of the interaction of order and list in mixed list backward recall was due to the tendency for the subjects in all groups to make more errors on the items from the list learned first. There was little evidence of selective perception, defined as a tendency to recall the items of one list whether it was learned first or second, by either RL group. Another possible source of selective perception, defined as the choice of acoustic or graphic stimulus terms where the probe in recall was a response term common to both lists, showed no difference between RL groups in their choice of stimulus terms.

The facilitative effect of the auditory-acoustic combination was found in backward recall and in learning. The interference effect observed in the auditory-graphic combination was also found in both recall and learning. The VV group, however, recalled items from both lists with about the same number of errors, a finding also true of the VA group. In learning trials, the VV-acoustic combination required more trials than the VV-graphic combination, leading to the conclusion that the pairs learned visually were less subject to forgetting than the auditorially presented pairs.

The carry-over effect when the initially difficult-to-learn AA-graphic combination was presented and then followed by the AA-acoustic presentation may in some way parallel the situation described by Cohen (1967): "We know from abundant experience that once hooked on a sight approach to reading, retarded readers are extremely difficult to move to a phonic and structural approach to word attack."

Conclusions

In learning and recall, there was no evidence that information presented visually and auditorially is poorly integrated by retarded readers. The intersensory integration theory as stated by Birch was not supported by the results of this study.

The relationship between reading ability and the results of Birch's AVI task, in which taps are presented and the subject then finds the corresponding dot pattern, can be accounted for if it is assumed that successful performance in the AVI task depends upon (1) visual processing of the auditorially presented tap pattern, or (2) transformation of the visually presented dot patterns to auditory process before the auditory stimulus trace has faded from short-term memory. The results of the present study tend to support the latter interpretation, since with visual presentation the high RL subject was more efficient at processing acoustic input, but when stimuli were presented auditorially, he was no more efficient in processing graphic input than the low RL subject.

It is concluded that if the concept of intersensory integration has any relationship to reading ability, it is that the concept must be interpreted in terms of first- _and_ second-order input. The integration accomplished by the individual that is crucial for reading cannot be generalized in terms of mode of presentation alone. To do so invites limitation of the child's perceptual environment without an understanding of the benefits of bimodal presentation with control of critical features of second-order input.

The grapheme-phoneme unit of Gibson's form of integration theory fulfills the requirement that second-order input be defined. The results of this study are in agreement with Gibson's view of the way in which the grapheme-phoneme unit functions in beginning reading.

The second major finding was the severe effect on subsequent learning and backward recall when auditory presentation procedures and material with graphic critical features were combined. A marked carry-over effect was found when the AA-graphic combination was followed by the normally facilitative AA-acoustic combination.

The third major finding of the study was that type of list and order of list presentation did not affect the rate of learning in the VA condition as in the single-modal conditions. The simultaneous presentation of visual and auditory stimulus and response terms appeared to escape the interference effects found in the AA presentation as well as the difficulty in detection of the acoustic features in the VV presentation.

The fourth finding of interest was that good and poor readers differed in their rate of learning the pairs but did not differ in degree of retention.

The analysis did not provide a satisfactory explanation of the slower rate of acquisition of the low RL subjects. Further research, perhaps a study to investigate short term memory in good and poor readers presented with terms with varied attributes of similarity, should be directed toward this problem.

REFERENCES

Bateman, B. Learning disorders. Review of Educational Research, 1966, 36, 93-119.

Battig, W.F. and Spera, A.J., Rated association values of numbers from 0-100. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 200-202.

Beery, J.W. Matching of auditory and visual stimuli by average and retarded readers. Child Development, 1967, 38, 827-833.

Birch, H. G. Dyslexia and the maturation of visual function. In Reading Disability: Progress and Research Needs in Dyslexia, John Money, Ed. Baltimore: Johns Hopkins Press, 1962.

Birch, H. G. and Belmont, L. Auditory-visual integration in normal and retarded readers. American Journal of Orthopsychiatry, 1964, 34, 852-861.

Birch, H. G. and Belmont, L. Auditory-visual integration, intelligence, and reading ability in school children. Perceptual and Motor Skills, 1965, 20, 295-305.

Birkemeyer, F. The relationship between the Coloured Progressive Matrices and the Wechsler Intelligence Scale for Children. Psychology in the Schools, 1965, 2, 278-280.

Blank, M. and Bridger, W. H. Deficiencies in verbal labeling in retarded readers. American Journal of Orthopsychiatry, 1966, 36, 840-847.

Blank, M., Weider, S., and Bridger, W. H. Verbal deficiencies in abstract thinking in early reading retardation. American Journal of Orthopsychiatry, 1968, 38, 823-834.

Blank, M. and Klig, S. Dimensional learning across sensory modalities in nursery school children. Journal of Experimental Child Psychology, 1970, 9, 166-173.

Budoff, M. and Quinlan, D. Reading progress as related to efficiency of visual and aural learning in the primary grades. Journal of Educational Psychology, 1964, 55, 247-252.

Butenica, N. A. Perceptual mode dominance: an approach to assessment of first-grade reading and spelling. Paper presented to American Psychological Association, San Francisco, Sept. 1968.

Cohen, S. Alan. Some conclusions about teaching reading to disadvantaged children. Reading Teacher, 1967, 20, 433-435.

Denison, J. W. Perceptual influences in the primary grades: an alternative consideration. Journal of School Psychology, 1969, 7, 38-46.

Dykstra, R. Summary of the second-grade phase of the Cooperative Research Program in primary reading instruction. Reading Research Quarterly, 1968, 4, 49-70.

Evans, J. R. Auditory and auditory-visual integration skills as they relate to reading. Reading Teacher, 1969, 22, 625-629.

Ford, M. P. Auditory-visual and tactual-visual integration in relation to reading ability. Perceptual and Motor Skills, 1967, 24, 831-841.

Gibson, J. J. and Gibson, E. J. Perceptual learning: differentiation or enrichment? Psychological Review, 1955, 62, 33-40.

Gibson, E. J., Gibson, J. J., Pick, A. D., and Osser, H., A developmental study of the discrimination of letter-like forms. Journal of Comparative Physiology and Psychology, 1962, 55, 897-905.

Gibson, E. J., Pick, A., and Osser, H. and Hammond, M. The role of grapheme-phoneme correspondence in the perception of words. American Journal of Psychology, 1962, 75, 554-570.

Gibson, E. J., Bishop, C. H., Schiff, W. and Smith, J. A comparison of meaningfulness and pronounciability as groupingprinciples in the perception and retention of verbal material. Journal of Experimental Psychology, 1964, 67, 173-182.

Gibson, E. J., Osser, H. and Pick, A. A study of the development of grapheme-phoneme correspondences. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 142-146.

Giebink, John W. and Goodsell, L. L. Reading ability and associative learning for children with a visuomotor deficit. American Educational Research Journal, 1968, 5, 412-420.

Golden, N. E. and Steiner, S. R. Auditory and visual functions in good and poor readers. Journal of Learning Disabilities, 1969, 2, 46-51.

Gumenik, W. E. Effects of articulatory activity and auditory, visual, and semantic similarity on the short term memory of visually presented paired associates. Journal of Experimental Psychology, 1969, 82, 70-74.

Jensen, A. R. Social class and perceptual learning. Mental Hygiene, 1966, 50, 226-239.

Kahn, D. and Birch, H. G. Development of auditory-visual integration and reading achievement. Perceptual and Motor Skills, 1968, 27, 459-468.

Katz, P. A. and Deutsch, M. Relation of auditory-visual shifting to reading achievement. Perceptual and Motor Skills, 1963, 17, 327-332.

Kirk, R. E. Experimental Design Procedures for the Behavioral Sciences. Belmont, Calif.: Brooks/Cole, 1968.

Montague, W. E. and Kiess, H. W. The associability of CVC pairs. Journal of Experimental Psychology Monograph Supplement, 1968, 78, 1-23.

Muehl, S. and Kremenak, S. Ability to match information between auditory and visual sense modalities and subsequent reading achievement. Journal of Educational Psychology, 1966, 57, 230-239.

Otto, W. The acquisition and retention of paired associates by good, average and poor readers. Journal of Educational Psychology, 1961, 52, 241-248.

Paivio, A. and Yuille, J. C. Word abstractness and meaningfulness, and paired associate learning in children. Journal of Experimental Child Psychology, 1966, 4, 81-89.

Pick, H. L. Jr., Pick, A. D., and Klein, R. E. Perceptual integration in children. In Advances in Child Development and Behavior, Vol. 3, Lipsitt, L. P., and Spiker, C. S., eds., New York: Academic Press, 1967.

Rudel, R. G. and Tueber, H. Crossmodal transfer of shape discrimination by children. Neuropsychologica, 1964, 2, 1-8.

Rudnick, M., Sterritt, G. M. and Flax, M. Auditory and visual rhythm perception and reading ability. Child Development, 1967, 38, 581-587.

Schulz, R. W. and Hopkins, R. J. Presentation mode and meaningfulness as variables in several verbal learning tasks. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 1-13.

Sterritt, G. M. and Rudnick, M. Auditory and visual rhythm perception in relation to reading ability in fourth grade boys. Perceptual and Motor Skills, 1966, 22, 859-864.

Trieschmann, Roberta B. Undifferentiated handedness and perceptual development in children with reading problems. Perceptual and Motor Skills, 1968, 27, 1123-1134.

Uhl, N. P. and Nurss, J. R. Socio-economic styles in solving reading-related tasks. Reading Research Quarterly, 1970, 5, 452-485.

Van Mondfrans, A. P. and Travers, R. M. W. Paired associate learning within and across sense modalities and involving simultaneous and sequential presentations. American Educational Research Journal, 1965, 2, 89-99.

Wepman, J. M. The perceptual basis for learning. In Meeting Individual Differences in Reading, H. A. Robinson, Ed. Chicago: University of Chicago Press, 1964.

Wickelgren, W. A. Distinctive features and errors in short term memory for English consonants. Journal of the Acoustical Society of America, 1966, 39, 388-398. (a)

Wickelgren, W. A. Short-term recognition memory for single letters and phonemic similarity of retroactive interference. Quarterly Journal of Experimental Psychology, 1966, 18, 55-62. (b)

Whipple, C. and Kodman, F. Jr. A study of discrimination and perceptual learning with retarded readers. Journal of Educational Psychology, 1969, 60, 1-5.

Winer, B. J. Statistical Principles in Experimental Design. New York: McGraw Hill, 1962.

Witkin, B. R. Auditory perception - implications for language development. Journal of Research and Development in Education, 1969, 3, 53-71.

APPENDIX

TABLE A-1

Means and Standard Deviations of Each of the Twelve Groups (N = 6): Number of Trials to Criterion

Group			Acoustic List		Graphic List	
	Mode	Order	$\bar{X}$	S.D.	$\bar{X}$	S.D.
	Auditory	1	3.83	1.47	5.17	2.32
	Auditory	2	10.33	2.94	11.33	4.84
High Reading Level	Visual	1	6.67	3.72	4.17	1.72
	Visual	2	7.67	5.20	5.67	3.14
	Visual-Aud.	1	6.83	1.72	5.00	2.10
	Visual-Aud.	2	5.67	3.33	7.00	4.20
	Auditory	1	9.17	4.75	8.83	2.71
	Auditory	2	9.17	3.13	10.17	3.54
Low Reading Level	Visual	1	13.17	3.37	7.83	4.17
	Visual	2	10.00	2.90	6.50	2.88
	Visual-Aud.	1	6.67	4.23	8.00	3.10
	Visual-Aud.	2	7.17	2.64	7.17	4.67

TABLE A-2

Means and Standard Deviations of Each of the Twelve Groups (N = 6): Number of Errors on Immediate Backward Recall Tests

Group			Acoustic List		Graphic List	
	Mode	Order	$\bar{X}$	S.D.	$\bar{X}$	S.D.
	Auditory	1	1.83	1.83	2.67	2.34
	Auditory	2	5.33	5.50	7.17	6.15
High Reading Level	Visual	1	3.17	4.25	1.83	2.23
	Visual	2	3.00	3.03	2.17	2.64
	Visual-Auditory	1	2.67	2.50	2.00	1.67
	Visual-Auditory	2	2.33	3.50	2.00	2.53
	Auditory	1	4.17	3.87	5.17	5.56
	Auditory	2	3.00	2.68	4.00	2.53
Low Reading Level	Visual	1	4.83	3.13	2.67	3.08
	Visual	2	4.83	3.97	2.67	2.16
	Visual-Auditory	1	1.83	2.99	3.83	3.87
	Visual-Auditory	2	4.50	4.23	4.67	5.20

TABLE A-3

Means and Standard Deviations of Each of the Twelve Groups (N = 6): Number of Errors on the Mixed Lists Backward Recall Test

Group			Acoustic List		Graphic List		Either List	
	Mode	Order	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
	Auditory	1	2.00	1.90	1.83	1.60	2.33	2.25
	Auditory	2	3.17	2.93	6.17	2.56	4.50	3.73
	Visual	1	2.83	3.66	0.17	0.41	1.33	1.75
High Rdg. Lvl.	Visual	2	2.50	3.33	3.17	3.49	1.50	1.52
	Visual-Aud.	1	2.83	3.06	0.67	1.21	1.83	1.83
	Visual-Aud.	2	0.33	0.81	3.33	2.80	1.00	2.45
	Auditory	1	3.33	3.08	3.67	3.33	3.83	2.79
	Auditory	2	0.83	1.33	5.67	2.58	2.50	2.07
	Visual	1	5.33	3.33	2.67	1.86	2.67	3.67
Low Rdg. Lvl.	Visual	2	2.00	2.28	3.83	2.32	3.50	3.02
	Visual-Aud.	1	1.67	1.97	1.67	1.86	1.67	2.42
	Visual-Aud.	2	1.50	1.97	4.67	2.88	3.00	1.90

TABLE A-4

The Proportion of Third- and Fourth-Grade Subjects Selecting the Number That Was the Classroom's Most Popular Response as Having Visual or Acoustic Similarity to a Given Letter

Pairs with Visual Similarity				Pairs with Acoustic Similarity			
Stimulus Letter	Number Chosen	3rd Grade Ss(N=22)	4th Grade Ss (N=24)	Stimulus Letter	Number Chosen	3rd Grade Ss (N=22)	4th Grade Ss (N=24)
H	4	.92	.86	N	9	.92	.90
S	8	.79	.69	C	3	.78	.52
G	6	.77	.73	Q	2	.60	.50
Z	7	.50	.45	K	8	.60	.50
M	3	.26	.53	F	5	.50	.35
B	3	.83	.14	X	6	.42	.45
B	8	.08	.73	B	3	.83	.39
C	6	.62	.55	J	8	.70	.31
F	7	.35	.46	Z	3	.65	.15
J	9	.43	.51	Z	6	-	.35
K	4	.29	.30	M	9	.16	.31
Q	9	.29	.34	G	3	.12	.28
R	8	.23	.13	H	8	.88	.21
N	4	.29	.18	S	6	.68	.70
X	4	.15	.18	R	4	.39	.30

FIGURE A-5

Size and Conformation of the Letters and Numbers
Making Up the Two Lists

Graphic List		Acoustic List	
Z	7	X	6
H	4	K	8
S	8	Q	2
G	6	C	3
T	1	N	9
M	3	F	5